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EXTINCTION BY DIELECTRIC PARTICLES AT OPTICAL AND
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OF BIOENGINEERING P W BARBER 30 NOV 82 1

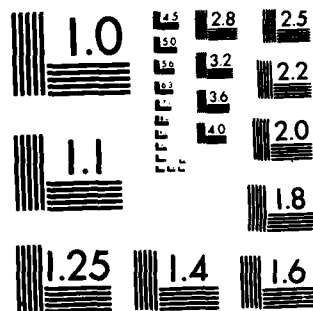
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20. Abstract

The light scattering properties of nonspherical particles have been investigated. A volume integral equation technique suitable for cubical or high axial ratio particles has been developed and tested. A hybrid differential-integral technique suitable for inhomogeneous particles has also been developed and tested. The elements of the Mueller matrix have been calculated for spheroids and super spheroids. A framework for parameterizing both particle shape and scattering output has been proposed as a mechanism for relating these two quantities. Graphical techniques permit rapid analysis of angular scattering results.



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Problem Statement

The goal of this project is to quantify the optical and infrared extinction properties of dielectric particles. Tasks include the development of new numerical methods and the use of these methods to analyze the polarized scattering and absorption characteristics of nonspherical particles.

Summary of Significant Results

1. Mueller Matrix Calculations.

We have calculated the eight nonzero elements of the Mueller matrix for a set of randomly oriented prolate superspheroids. We were able to show that all of the elements are almost equally sensitive to small deformations in shape. In particular, the S_{34} element does not appear to be uniquely sensitive to particle deformations, as has been indicated in some (limited) experimental results.

We have used the aerodynamic shape factor to parameterize particle shape. The elements of the Mueller matrix have been parameterized in a similar fashion. Calculations for prolate and oblate spheroids show that it should be possible to find a relationship between particle and scattering parameters, although there is an unresolved ambiguity between prolate and oblate particles which have identical aerodynamic shape factors. Also, a number of different approaches to classifying scattering results have been studied. Most are based on spectral decomposition of the angular scattering.

2. Scattering by Dust-type Particles.

An algorithm has been developed for calculating the scattering by particles which are cubical or can be constructed from cubes. Preliminary testing is complete, the correct small particle Rayleigh behavior was obtained. After further testing we intend to calculate the elements of the Mueller matrix for a variety of cubical and long cylindrical particles. One part of the investigation will compare the scattering by cubes and spheres to test the legitimacy of representing atmospheric dust particles by spheres.

3. Scattering by Inhomogeneous Particles.

The combined finite element integral equation method has for the first time been tested on nonspherical objects. The results, while not exact do prove that the method works. However, there are still a number of numerical problems which are proving difficult to overcome. Namely, the numerical differentiation and singularity problems described in previous reports. Furthermore, the computer memory and CPU time required to run the program are excessive. We are now deciding whether the method is going to be useful as a practical tool for scattering research.

4. Scattering Calculations for Large Particles.

We have successfully used the T-matrix method to make calculations for spheroidal ice crystal models with size parameters in the range of 20-30. These results have been compared with those for hexagonal cylinders to determine the effects of fine structure on the scattering phase matrix elements. We have also made a large number of calculations which will be compared with some experimental measurements on atmospheric aerosols.

List of Publications

1. P. W. Barber, J. F. Owen, and R. K. Chang, "Resonant Scattering for Characterization of Axisymmetric Dielectric Objects," IEEE Trans. Antennas Propag., 30, 168, 1982.
2. P. W. Barber and H. Massoudi, "Recent Advances in Light Scattering Calculations for Nonspherical Particles," in press, Aerosol Science and Technology.
3. M. A. Morgan, C. H. Chen, S. C. Hill and P. W. Barber, "Finite Element-Boundary Integral Formulation for Electromagnetic Scattering," submitted, Journal of Wave Motion.
4. K. N. Liou, Q. Cai, P. W. Barber, and S. C. Hill, "Scattering Phase Matrix Comparison for Randomly Oriented Hexagonal Cylinders and Spheroids," submitted, Applied Optics.

Scientific Personnel

P. W. Barber, Principal Investigator
H. Massoudi, Faculty Associate
P. Geller, Graduate Student
S. Hill, Graduate Student

P. Geller completed all requirements for a Master's degree in Electrical Engineering. The degree will be awarded at Commencement in June 1983.

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